# Remote Sensing and Prediction of the Coastal Marine Boundary Layer

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## LONG TERM GOALS

The long-term goal is to improve numerical (computer -aided) weather prediction in coastal regions, especially of weather events that impact naval operations.

## OBJECTIVES

We seek to forecast weather events in the right place and the right time. The weather events we are most concerned with are convective storms, boundary layer clouds and drizzle. A measurement of our success would be improved forecasts by the USN's mesoscale model COAMPS.

## APPROACH

1. Many of our approaches involve testing new schemes for physical processes in COAMPS.

2. An approach outside of COAMPS is to further develop single/dual Doppler retrieval/analysis/assimilation algorithms.

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## WORK COMPLETED

1. A basic proof-of-concept research project in dual-Doppler analysis has been completed. The scheme uses the vertical vorticity equation to improve estimates of the vertical velocity field.

2. The buoyant production of turbulent kinetic energy in COAMPS is made consistent with the prognostic thermodynamic variables. A non-local length scale is applied in the closure for diffusivity and dissipation. The entrainment rates produced by COAMPS for a clear, smoky and cloudy boundary layer are compared against independent LES calibrations. COAMPS is then used to make a forecast of mesoscale cellular convection in the Yellow Sea.

3. The Common Land Model (CLM) has been implemented into COAMPS. CLM is a combination of the Bonnan's NCAR CCSM (Community Climate System Model), Dickinson's BATS model and IAP94 (ice) model. CLM will become the new version of the land surface component of the NCAR CCSM. CLM has also been implemented into the new WRF (Weather Research and Forecasting) model by the Illinois Water Survey Group.

4. The development of a parameterization based on full moments of the drop spectra has continued. At present, we have implemented parameterizations of individual processes into the CIMMS LES model and the efforts are concentrating on debugging and testing the fidelity of formulation of each process by contrasting solutions with explicit and bulk microphysics.

5. COAMPS, equipped with the CIMMS bulk drizzle scheme, is able to produce breakup of marine stratocumulus for short timescales at a horizontal grid spacing of 2 km. The presence of drizzle accelerates the breakup compared to that seen when stratocumulus clouds are advected over water with progressively warmer SSTs. Cloud breakup is manifested as a transition from unbroken stratocumulus to a broken, boundary layer cumulus regime.

6. Modifications to the turbulence parameterization reduce the in-cloud lapse rate and result in a more realistic treatment of the cumulus regime, specifically more reasonable values of liquid water path, surface drizzle rate, cloud base height, and convective element intensity.

7. COAMPS shows sensitivity to the depletion of CCN and a weak sensitivity to transient features in the surface fluxes arising from the effects of drizzle.

8. A simple treatment of sub-grid variability for the autoconversion process has been derived and implemented into COAMPS. On the 2 km mesh, including information about sub-grid variability results in increased autoconversion rates that lead to enhanced drizzle production and a reduction in liquid water path. Simulated low cloud cover becomes less persistent when using the PDF formulation (Figure 2). Enhanced breakup is particularly obvious in values of cloud fraction, 0.93 for the control run and 0.78 for the sub-grid PDF treatment. Stronger drizzle ultimately leads to a more robust convective mode that acts in the model as a positive feedback on cloud breakup, with increased subsidence outside the resolved convective elements results in increased dissipation of the stratocumulus deck.

## RESULTS

1. The results from single-Doppler analysis suggest that a significant improvement in retrieval error statistics can be achieved as the volume scan times decrease from 5 minutes (characterizing the current WSR-88D scan rates) down to 1 minute, the fastest scan rates available from the Doppler-on-Wheels at the time of the field deployments. The trend suggests that even greater improvements might be attained with the faster scan rates available from phased array weather radars.

2. Results from dual-Doppler analysis with simulated storm data show that the vorticity equation can be successfully combined with the mass conservation equation in a variational framework to "add value" to estimates of the vertical velocity field. The greatest added value occurs in cases where data do not extend down to ground level (i.e., in cases where the impermeability condition cannot be safely applied).

3. The modified scheme for turbulent kinetic energy in COAMPS performs as well as other TKE/length-scale schemes have in recent comparisons with LES-based calibrations. The new scheme also performs well outside the boundary layer, as indicated by simulations of thunderstorms that compare favorably with ARPS. The modified scheme also produces a realistic breakup of a stratocumulus cloud-deck in a simulation of a cold air outbreak in the Yellow Sea.

4. The modified microphysics schemes continues the improvement of the representation of low clouds in COAMPS.

## IMPACT

We expect to be successful in offering to the meteorological community improvements for numerical weather prediction of storms, boundary layer clouds and drizzle. We will offer to ONR a version of COAMPS containing all of our upgrades. We also will be able to deliver a valuable algorithm for extracting three-dimensional winds from a single-doppler radar.

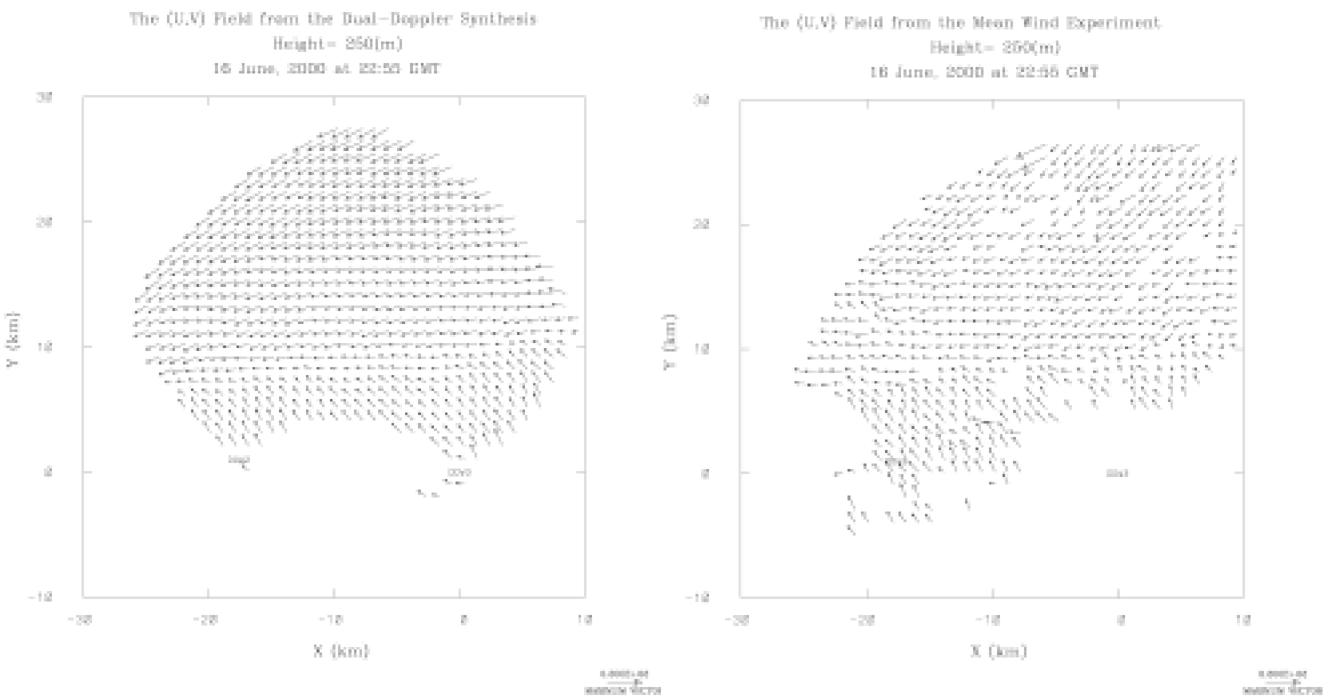


***Figure 1 Left: dual-doppler analyzed wind field. Right single-doppler analysis of the same windfield using only the radar on the right, DOW3.***

## TRANSITIONS

Our COAMPS source code is in a branch of the CVS archive, and should be easy to assimilate by NRL Monterey. We mention here several additional aspects of COAMPS that were examined and upgraded: the advection schemes, the finite-difference grid and the conservation properties of the mixing terms.

## SUMMARY

The weather forecast model COAMPS will be better able to forecast stratocumulus clouds and drizzle as a result of this project. This project also played a pioneering role in the release of COAMPS for use outside the USN, and trained a number of scientific personnel in the use of COAMPS.

## RELATED PROJECTS

We work closely with the personnel of OU's Center for Analysis and Prediction of Storms, the Oklahoma Climate Survey (Mesonet), and the Marine Meteorology Division of the Naval Research Laboratory.

**PUBLICATIONS**

CMRP support is acknowledged in 16 refereed publications that have been accepted or conditionally accepted, and 40 conference preprints. Three notable papers are:

Fiedler, B. H., 2001: Grid adaption and its effect on entrainment in an E-l model of the atmospheric boundary layer. Accepted for publication in *Mon. Wea. Rev*.

Mechem, D. B., Y. L. Kogan, and L. Yi, 2001: Simulating breakup of marine stratocumulus with a mesoscale model. In preparation for *Mon. Wea. Rev.*

Mewes, J. J., and A. Shapiro 2001: On use of the vorticity equation in dual-Doppler analysis of the vertical velocity field. Accepted for publication in *J. Atmos. And Oceanic Technol.*